Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina

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REGIONAL AQUIFER-SYSTEM ANALYSIS

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HYDROGEOLOGIC FRAMEWORK OF THE FLORIDAN AQUIFER SYSTEM IN FLORIDA AND IN PARTS OF GEORGIA, SOUTH CAROLINA, AND ALABAMA

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ABSTRACT

The Floridan aquifer system of the Southeastern United States is comprised of a thick sequence of carbonate rocks that are mostly of Paleocene to early Miocene age and that are hydraulically connected in varying degrees. The aquifer system consists of a single vertically continuous permeable unit updip and of two major permeable zones (the Upper and Lower Floridan aquifers) separated by one of seven middle confining units downdip. Neither the boundaries of the aquifer system or of its component high- and low-permeability zones necessarily conform to either formation boundaries or time-stratigraphic breaks.

The rocks that make up the Floridan aquifer system, its upper and lower confining units, and a surficial aquifer have been separated into several chronostratigraphic units. The external and internal geometry of these stratigraphic units is presented on a series of structure contour and isopach maps and by a series of geohydrologic cross sections and a fence diagram. Paleocene through middle Eocene units consist of an updip clastic facies and a downdip carbonate bank facies, that extends progressively farther north and east in progressively younger units. Upper Eocene and Oligocene strata are predominantly carbonate rocks throughout the study area. Miocene and younger strata are mostly clastic rocks.

Subsurface data show that some modifications in current stratigraphic nomenclature are necessary. First, the middle Eocene Lake City Limestone cannot be distinguished lithologically or faunally from the overlying middle Eocene Avon Park "Limestone." Accordingly, it is proposed that the term Lake City be abandoned and the term Avon Park Formation be applied to the entire middle Eocene carbonate section of peninsular Florida and southeastern Georgia. A reference well section in Levy County, Fla., is proposed for the expanded Avon Park Formation. The Avon Park is called a "formation" more properly than a "limestone" because the unit contains rock types other than limestone. Second, like the Avon Park, the lower Eocene Oldsmar and Paleocene Cedar Keys "Limestones" of peninsular Florida practically everywhere contain rock types other than limestone. It is therefore proposed that these units be referred to more accurately as Oldsmar Formation and Cedar Keys Formation.

The uppermost hydrologic unit in the study area is a surficial aquifer that can be divided into (1) a fluvial sand-and-gravel aquifer in southwestern Alabama and westernmost panhandle Florida, (2) limestone and sandy limestone of the Biscayne aquifer in southeastern peninsular Florida, and (3) a thin blanket of terrace and fluvial sands elsewhere. The surficial aquifer is underlain by a thick sequence of fine clastic rocks and low-permeability carbonate rocks, most of which are part of the middle Miocene Hawthorn Formation and all of which form the upper confining unit of the Floridan aquifer system. In places, the upper confining unit has been removed by erosion or is breached by sinkholes. Water in the Floridan aquifer system thus occurs under unconfined, semiconfined, or fully confined conditions, depending upon the presence, thickness, and integrity of the upper confining unit.

Within the Floridan aquifer system, seven low permeability zones of subregional extent split the aquifer system in most places into an Upper and Lower Floridan aquifer. The Upper Floridan aquifer, which consists of all or parts of rocks of Oligocene age, late Eocene age, and the upper half of rocks of middle Eocene age, is highly permeable. The middle confining units that underlie the Upper Floridan are mostly of middle Eocene age but may be as young as Oligocene or as old as early Eocene. Where no middle confining unit exists, the entire aquifer system is comprised of permeable rocks and for hydrologic discussions is treated as the Upper Floridan aquifer.

The Lower Floridan aquifer contains a cavernous high-permeability horizon in the lower part of the early Eocene of southern Florida that is called the Boulder Zone. A second permeable unit that is cavernous in part, herein called the Fernandina permeable zone, occurs in the lower part of the Lower Floridan in northeastern Florida and southeastern Georgia. Both these permeable zones are overlain by confining units comprised of micritic limestone. The confining unit that overlies the Boulder Zone is of subregional extent and is mapped as a separate middle confining unit within the Lower Floridan.

Major structural features such as the Southeast and Southwest Georgia embayments, the South Florida basin, the Gulf Coast geosyncline, and the Peninsular arch have had a major effect on the thickness and type of sediment deposited in the eastern gulf coast. The effects of smaller structures are also evident. For example, the Gilbertown-Pickens-Pollard fault system in Alabama locally forms the updip limit of the Floridan aquifer system. The series of grabens that comprise the Gulf Trough of central Georgia serves as a low-permeability barrier to ground-water flow there. These Gulf Trough faults have downdropped low-permeability rocks opposite permeable limestones to create a damming effect that severely retards ground-water movement across the fault system. Their

effect can be seen on potentiometric surface maps of the aquifer system. Other small-displacement faults in peninsular Florida do not appear to affect the regional flow system because there is no apparent change in the permeability of the rocks that have been juxtaposed by fault movement.

Variations in permeability within the Floridan aquifer system result from a combination of original depositional conditions, diagenesis, large- and small-scale structural features, and dissolution of carbonate rocks or evaporite deposits. Local permeability variations are accordingly more complex than the generalized regional portrayal presented in this report.

INTRODUCTION

PURPOSE AND SCOPE

In 1977 the U.S. Geological Survey began a nationwide program to study a number of the regional aquifers that provide a significant part of the country's water supply. This program, termed the Regional Aquifer-System Analysis (RASA), is discussed in detail by Johnston and Bush (1985). In brief, the general objectives of each RASA study are (1) to describe the ground-water system as it exists today and as it existed before development, (2) to analyze changes between present and predevelopment systems (3) to integrate the results of previous studies dealing with local areas or discrete aspects of the system, and (4) to provide some capability for evaluating the effects (particularly the hydraulic effects) that future ground-water development will have on the system. These objectives can best be met by a regional-scale digital computer simulation of the aquifer system, supplemented where necessary by more detailed subregional simulations and by interpretations of the distribution of observed water-quality variations. Because of its importance as a source of ground-water supply and because of various problems that have arisen from intensive use, the Floridan aquifer system of the Southeastern United States was among the first regional aquifer systems chosen for study.

The Floridan aquifer system is comprised of carbonate rocks of Tertiary age and includes but is not limited to the sequence of rocks generally called the "Floridan aquifer" in Florida and the "principal artesian aquifer" in Georgia. Tertiary limestones also yield water, locally in appreciable quantities, in parts of southwestern South Carolina and southeastern Alabama. These limestones are included in the Floridan aquifer system in this report. The approximate areal extent of the aquifer system is shown in figure 1. The system includes rocks of Paleocene to early Miocene age that combine to form a vertically continuous carbonate sequence that is hydraulically connected in varying degrees. Very locally, in the Brunswick, Ga., area, beds assignable to the uppermost part of the Upper Cretaceous System are included in the Floridan aquifer system. Over much of the area where the aquifer system crops out, it consists of one vertically continuous permeable unit. Downdip, the aquifer system generally consists of two major permeable zones, herein called the Upper Floridan aquifer and the Lower Floridan aquifer, that are separated by less-permeable rock of highly variable hydraulic properties (very leaky to virtually nonleaky). Hydraulic conditions for the aquifer system vary from confined to unconfined, depending upon whether the argillaceous middle Miocene and younger rocks that form the upper confining unit of the system have been breached or removed by erosion.

As one of several chapters of a Professional Paper describing different aspects of the Floridan aquifer system and discussing the results of computer simulations, this report presents the hydrogeologic framework of the aquifer system as determined from subsurface geologic and hydrologic data. The objectives of this part of the study were:

1. To identify the aquifer system regionally in terms of the geologic and hydrologic units that comprise it and to define its extent.

2. To delineate regional permeability variations within the aquifer system, primarily on the basis of rock composition and texture and, to a lesser extent, on the development of secondary (solution) porosity.

3. To establish the influence of geologic structure and of variation in rock type on the ground-water flow pattern of the aquifer system.

4. To identify and map regional stratigraphic units and to establish a correlation framework between surface and subsurface geologic units.

5. To determine variations in the geometry and physical makeup of the aquifer system that affect either hydraulic parameters or the water quality of the system.

PREVIOUS WORK

Numerous reports have been published, chiefly by the U.S. Geological Survey and State geological surveys, that discuss various aspects of the geology and ground-water resources of the study area. For the most part, the scope of these reports is local or subregional. Extensive lists of publications on the geology and hydrology of the Floridan aquifer system are contained in reports by Murray (1961), Stringfield